Thermal storage eliminates energy waste in existing district heating network

Minimising energy consumption of buildings is of major importance on the way to zero impact buildings. However, a more holistic approach to the actual energy system may prove to have an even greater effect.

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The Energy Central is the result of a cooperation between Grundfos and the local district heating company. [Photo: Anders Nielsen]

Earlier this year, Grundfos headquarters and the local district heating company inaugurated a joint system to store the surplus heat from the Grundfos factories in obsolete groundwater boreholes, and use it in the district heating network when needed.

The synergy between the cooling demand in Grundfos' production plants and the heat demand of Bjerringbro district heating company has virtually eliminated energy waste. The remarkable reduction of energy consumption, CO_2 emission and operational costs now benefit both companies and the district heating customers in the area.

As part of the agreement, a new energy central with state-of-the-art cooling compressors and heating pumps has been established.

The new setup is based on three elements:

1. Exploitation of surplus heat from cooling in the factories.
2. Indirect storage of heat in an underground aquifer.
3. Heat pumps supply additional heat, when required

Central and efficient cooling function

Using small, individual refrigeration compressors to cool down machines in production facilities is a very inefficient, but nevertheless very common method. To make matters worse, the heat energy developed in the process is virtually always wasted.

With the new shared Energy Central, Grundfos productions facilities are cooled by cold water from the District heating network. And when the cold water needs to be colder, three large cooling compressors with a total cooling capacity of 2.85 MW and thermal power of 3.65 MW handle the job from a central facility.

Cooling compressors.

During the heating season, the cold water used to cool the machines at Grundfos, becomes hot in the process, and along with the excess heat from the cooling compressors in the energy central, the heat is recycled and sent directly to the district heating network.

Storing surplus heat under ground

During summer, when the heating demand is minimal, the surplus heat is stored in underground energy storage - a so-called ATES-stock (Aquifer Thermal Energy Storage) located 80 metres underground.

During the four summer months, a total cooling output of 3 500 MWh is accumulated. And more than 80% of the stored energy during summer will be supplied to the district heating network during the heating season. In fact, the energy central covers more than 15% of the town's annual heat requirement, of which 1/3 comes from the hot water storage.

The system

Frequency controlled

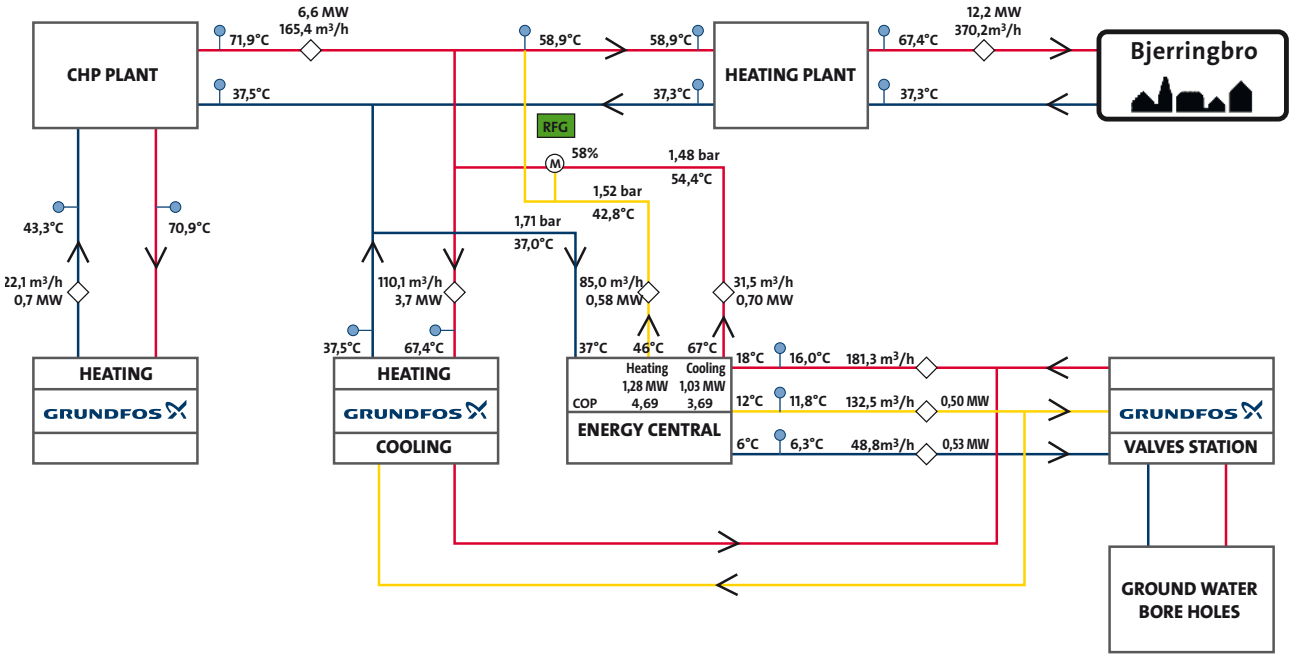
Pressure drops across valves in a heating system are costly and waste energy. This system however, is frequency controlled and designed for completely open valves. Accordingly, all thermal adjustments are carried out, by speed controlled pumps. As a result, pressure drop across the valves have been completely eliminated and replaced by massive energy savings.

Savings of up to 90%

The ATES system will reduce Grundfos' energy consumption for cooling by up to 90%. Combined with significantly reduced heating costs, the result is cheaper

Technical and performance data for the system

Number of bore holes	5
Amount of circulated water in groundwater systems (max)	160 m³/h
Amount of circulated water per year	1.5 mill. m³/year
Groundwater temperature	9°C
Aquifer cooling capacity before exchange	1.5 MW
Average COP for cooling (aquifer)	46
Average COP for heating (energy central)	4.6
Average COP for cooling (energy central)	3.6



Flow chart of Bjerringbro district heating and cooling network which supplies Grundfos production plants with ground water thermal storage, district heating network and heat pumps (in the energy central in the figure) for additional heating and cooling (compressors in the figure next page). The water used for cooling in the Grundfos factories is 6-12°C and 18°C when returned to the central. The temperature of the water is raised to 46/67°C with heat pumps and supplied to the district heating network. COP for heat pumps for heating is 4.60.

Cooling compressors.

heating for the citizens and massive energy savings for Grundfos and the district heating plant.

In fact, the carbon emission will be reduced by some 3,700 tonnes a year, equivalent to 1.5 tonnes per household connected to the heating plant.

Payback time

In total, Grundfos and Bjerringbro district heating company have invested 4.5 mill. euro in the new system. Without this joint investment, two separate systems would have been the solution. Compared to these reference systems, annual savings of 400 000 euro was initially expected, but because the system seems to be more efficient than estimated, the payback time will most likely be shorter than the projected 11.25 years.

With the new setup Bjerringbro district heating company seizes the opportunity to store energy and become less dependent on natural gas. As a result, the plant will emit less CO_2 and be able to offer more sustainable heating supply even lower price.

A model for future heating and cooling

Many European countries aim to be free from the use of fossil fuels in the near future, and this type of system is a big step in that direction. The system is able to store solar heat and thus, in principle, low fossil heat as it runs only on electricity. In the future, this may be supplied by wind turbines or any other renewable source.

According to Lars Hummelmose of the Danish Board of District Heating, this solution will hopefully inspire others to explore local environmental friendly energy opportunities. He sees many elements of the project that can be used globally, especially in countries that already have district heating, but also in countries that are facing a transition away from nuclear power. ■

Economics of the investment

Annual cooling output of groundwater cooling – 4 summer months (*Groundwater cooling covers cooling of all factories*).	3 500 MWh
Annual heat production of the cooling machines	13 400 MWh
Annual cooling output of cooling machines – 8 months	10 500 MWh
Total investment	4.5 mill. Euro
Estimated annual savings	400 000 Euro
Total annual reduction in carbon emissions	3 700 ton